Electronic determination of root canal length in primary teeth with and without root resorption

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Abstract

Mente J, Seidel J, Buchalla W, Koch MJ. Electronic determination of root canal length in primary teeth with and without root resorption. *International Endodontic Journal*, **35**, 447–452, 2002.

Aim To test an electrical device for determining root canal length in primary teeth *in vitro*, and to compare it with the radiographic length measurement.

Methodology Two examiners determined the root canal length of 24 extracted maxillary primary incisors (12 with visible root resorption and 12 without) using an electrical root canal meter (Tri Auto ZX, Morita, Dietzenbach, Germany). The instrument was left in the root canal after the second examination and a radiograph was taken. The whole tooth was cleared by immersion in methylsalicylate and subsequently photographed. Both radiographs and photographs of cleared teeth were measured and compared with the electronic measurements.

Results The evaluation of the radiographs showed a mean distance between the instrument tips and apices of 0.60 (± 0.41) mm; evaluation of the cleared teeth showed an equivalent distance of 0.62 (± 0.40) mm. The mean distance between instrument tip and acceptable working length (determined with the clearing method) was 0.26 (± 0.24) mm in teeth without resorption and 0.29 (± 0.30) mm in teeth with resorption.

Conclusion The presence of resorption in primary teeth did not affect the accuracy of electrical measurement of root canal length *in vitro*. The application of this method in primary teeth should be evaluated further.

Keywords: apex localization, electric endometry, endodontic treatment, primary teeth, resorption.

Received 29 January 2001; accepted 25 June 2001

Introduction

Pulpectomy is an important treatment option in primary teeth with infected pulps (Fuks & Eidelman 1991, Yacobi *et al.* 1991). Although pulpectomy is generally accepted as a safe procedure for primary teeth (Coll & Sadrian 1996), various factors must be borne in mind before starting treatment: long appointments may be tiring for young patients and the results of diagnostic procedures which require a child's cooperation (e.g. vitality testing) are less reliable compared with adult patients (Nowak 1999).

There are also specific problems which are characteristic of primary teeth: root canal walls are often thin and instrumentation of the canal may result in perforation or root fractures. In addition, the primary teeth are resorbed during eruption of their permanent successors.

Radiographic determination of root canal length may give misleading results when lateral canals are present. Therefore, one of the critical aspects of pulpectomy in primary teeth is the presence of root resorption (Coll & Sadrian 1996). Minor degrees of resorption may not be obvious radiographically and more extensive resorption should be considered as a contraindication for root canal treatment (Nowak 1999). Electric root length determination may be helpful in overcoming the shortcomings of radiographic examination in teeth with resorption. The aim of this study was to evaluate whether initial resorption of primary teeth affects the accuracy of an electrical root canal measuring device.

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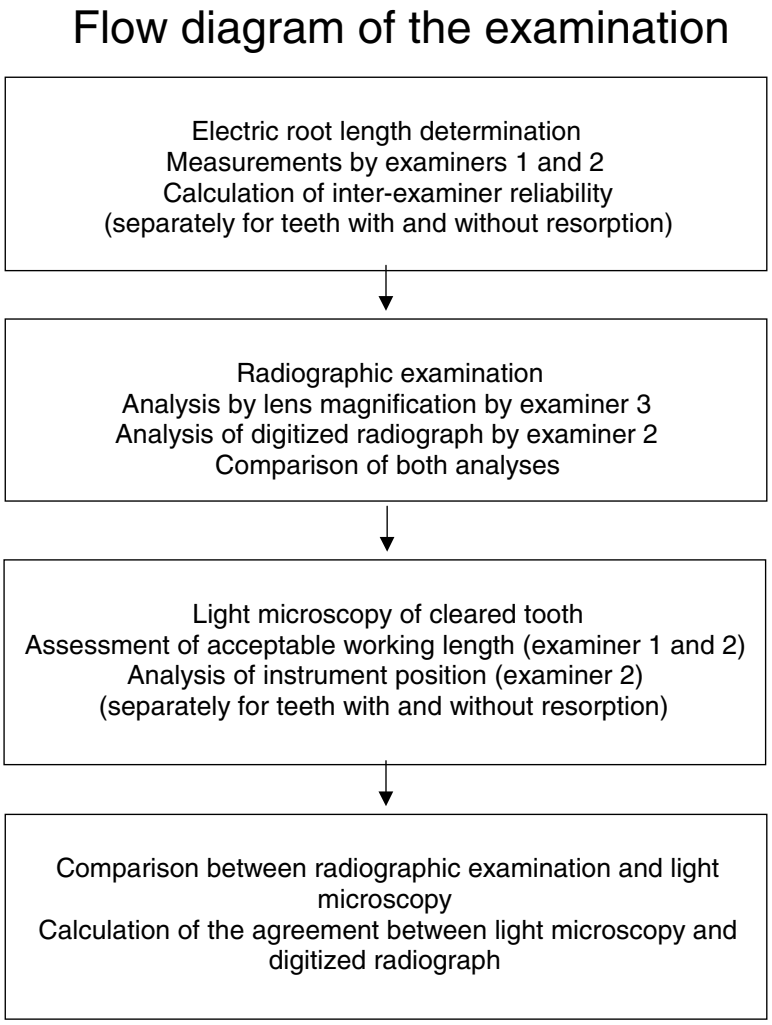

Figure 1 Flow diagram of the different steps of the study.

Materials and methods

Twenty-four extracted maxillary primary incisors were selected and stored in 4% formaldehyde solution for up to 4 weeks before examination. An overview of the methodology is given in Figure 1. Half of the teeth ($n = 12$) showed obvious signs of external resorption. The teeth were placed in the aperture of the lid of a high-density polyethylene vessel containing 35 mL 0.9% saline in such a way that the root was completely submersed in saline (Weiger *et al.* 1999). At the bottom of the vessel a metal screw was connected to one electrode of a Tri Auto ZX device (Morita, Dietzenbach, Germany). The Tri Auto ZX device is an apex locator that simultaneously calculates the ratio of two impendances in the same canal using two different frequencies (Vajrabhaya & Tepmongkol 1997). The crowns of the teeth were shortened using a diamond bur to obtain a defined reference point. Two examiners (J. M. and M. J. K.) independently determined root canal length. A size 053 K-file or 073 Hedstroem file (VDW, Munich, Germany) was connected to the second electrode of the Tri Auto ZX device. The diameter of the endodontic instrument was chosen according to the canal size (between ISO 30 and 90); no preparation of the canal was performed. The endodontic instrument was inserted until the 0.5 mm distance diode became illuminated. The penetration depth of the instrument was marked using a silicone stop and measured using a millimetre scale. Care was taken not to remove pulpal tissue during instrumentation of the canal in order to ensure that the situation for the second examination was identical. The values were recorded to an accuracy of 0.5 mm.

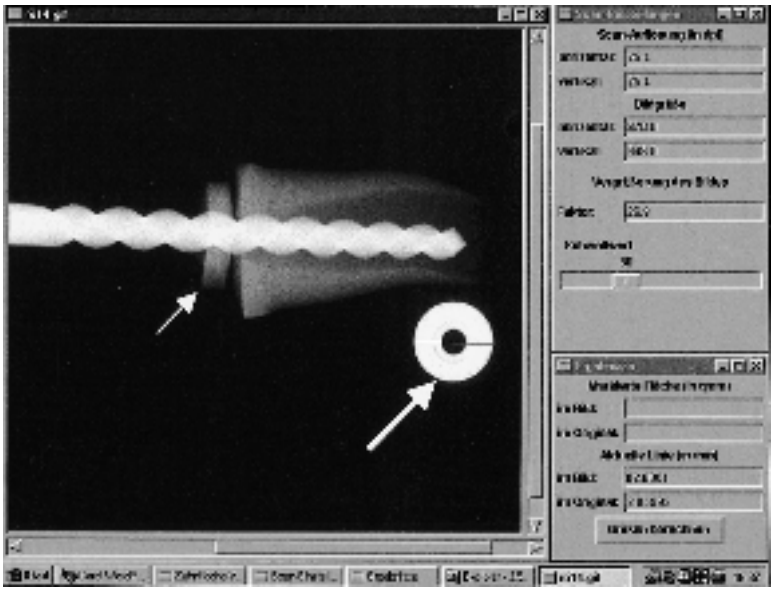

Figure 2 *In vitro* radiograph of a tooth (resorption group) with a metal stopper (Ø = 3.05 mm – large arrow) for calibration and a silicon stopper for length determination (small arrow).

Radiographic examination

After the second electronic measurement of root canal length, the instrument was inserted to the previously determined length. A radiograph of the tooth was exposed with an instrument *in situ* (K-file or Hedstroem-file) and a metal stopper (3.05 mm in diameter, Fig. 2) for reference using a 60-kV tube (Heliodent DS, Sirona, Bensheim, Germany; exposure time 0.16 s) and an Ultra Speed D film (Eastman Kodak, Rochester NY, USA). Films were developed using an XR 24 Nova (Dürr Dental, Bietigheim-Bissingen, Germany) device. A third examiner (J. S.), using a lens with 2-fold magnification, estimated the distance between the acceptable working length and the instrument tip on the radiographs. The acceptable working length was defined as the point at which the apical constriction was reached. In those cases where resorption had occurred (e.g. Fig. 2) and/or where there were lateral orifices, the acceptable working length was defined as that point where the instrument was just surrounded by dentine in the right-angled projection of the root axis. The radiographs were then digitized using a scanner (CanoScan 2700F, Canon, Tokyo, Japan) at a resolution of 970 × 648 dpi. The digitized radiographs were also analysed for the distance between instrument tip and maximum acceptable working length. For this purpose a software program for endometric measurements (Square Root! 2.0, Brücklmeier & Nolt, Berlin, Germany) was used as described previously (Buchalla *et al.* 1999). The agreement between radiographic and the electric measurement was calculated.

Clearing

After the radiograph was taken, the teeth with the endodontic instrument were dehydrated step-wise by immersion in varying concentrations of ethanol (80%, 90%, 95%, 100%) for 12-hour periods and subsequently immersed in methylsalicylate for 24 h. After clearing, the teeth were photographed at a magnification of 2× and the resulting slides were scanned at a resolution of 970 × 648 dpi. These digitized images were analysed for distance between tip of instrument and acceptable working length, and tip of instrument and tip of the root, using the same endometric software (SquareRoot! 2.0).

Statistical analysis

Statistical analysis was performed using SPSS for Windows 10.0 (SPSS Inc., Chicago, IL, USA). Inter-examiner reproducibility of the electric root length measurement was analysed with Cronbachs α intra class correlation coefficient, confidence interval, and inter–item reliability coefficient.

Results

Reproducibility of electrical root canal length determination

Overall agreement between the two examiners was good. For primary teeth without visible resorption the single intraclass correlation (Cronbachs alpha) was 0.95 (95% confidence interval 0.85–0.99). The correlation was

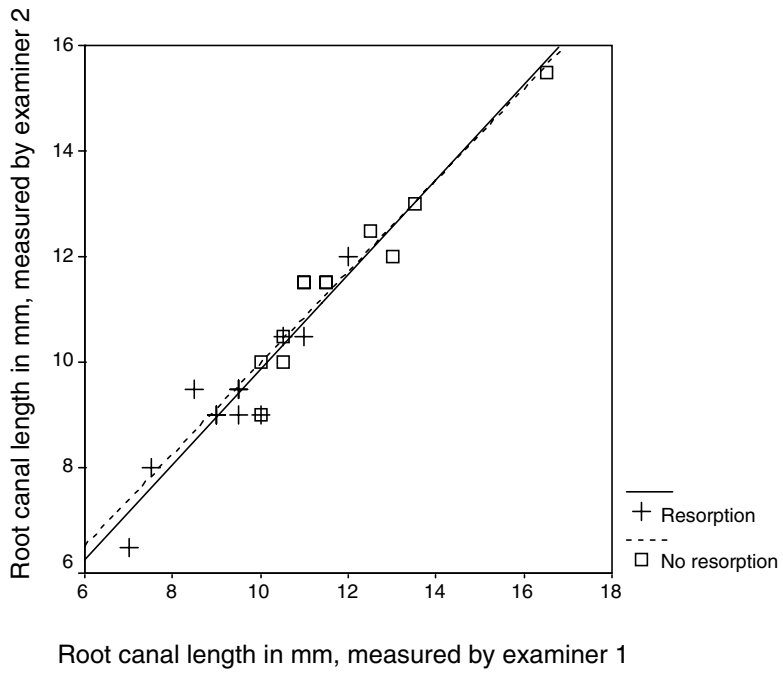

Figure 3 Inter-examiner agreement of electric endometry. (——) = matching line of the resorption group; (- - - - -) = matching line of the group without resorption.

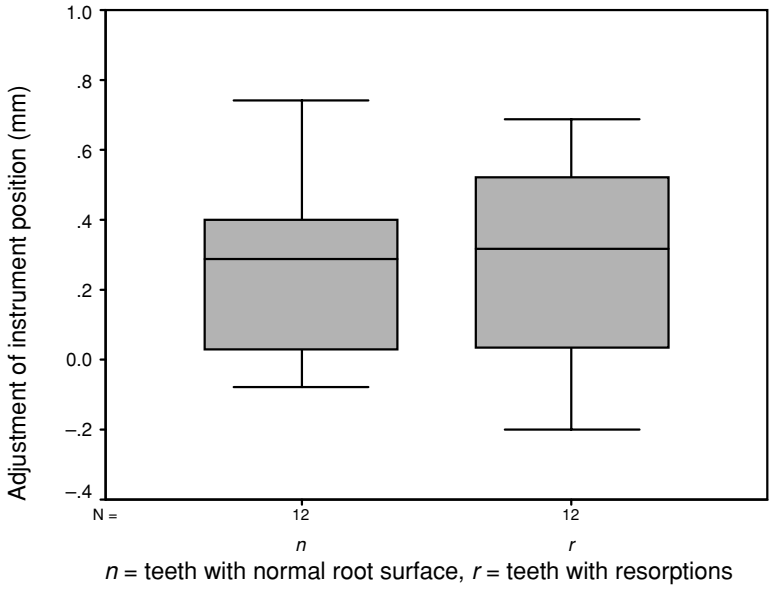

Figure 4 Difference (median and quartiles) between the maximal acceptable working length established by light microscopy of the teeth following clearing and the working length established by endometry.

$\alpha = 0.93$ (95% confidence interval 0.78–0.98) for teeth with resorption. There was high agreement between the two examiners in both groups (Fig. 3).

Radiographic examination

Agreement between the radiographic evaluation of distance between instrument tip and the acceptable working length established by using magnification of the conventional radiograph compared to analysis of the digitized radiograph was good; The interitem reliability coefficient was $\alpha = 0.85$ (Fig. 3).

Evaluation of teeth following clearing

Inter-examiner agreement of the acceptable working length was $\alpha = 0.92$.The mean distance between the instrument tip and acceptable working length was 0.26 mm (95% confidence interval for mean 0.11–0.41) for teeth without resorption and 0.29 mm (95%

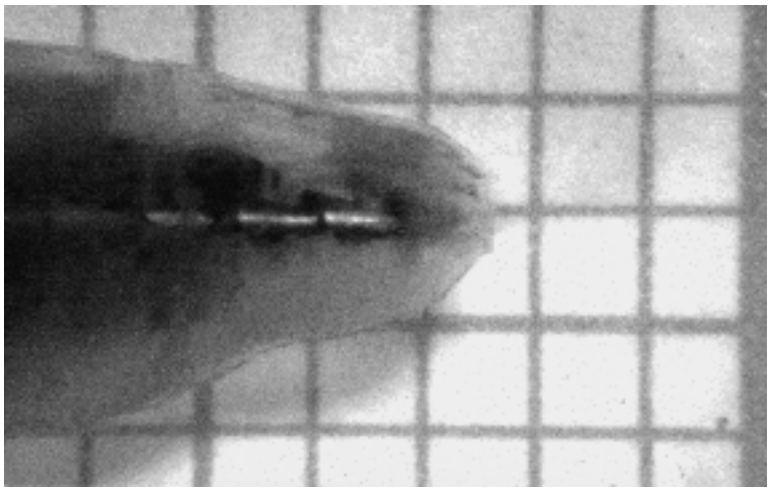

Figure 5 Cleared tooth without resorption.

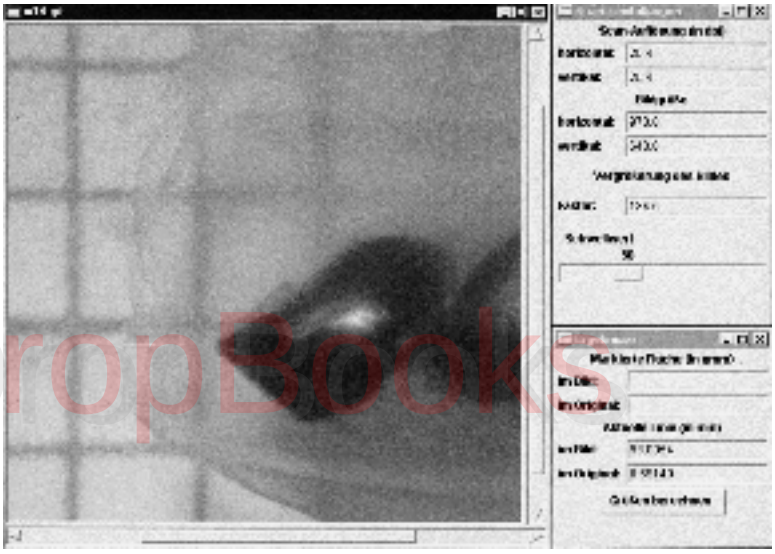

Figure 6 Cleared tooth with resorption. The instrument tip just reaches an acceptable working length.

confidence interval 0.11–0.47) for teeth with resorption (Fig. 4).

In general, the cleared teeth showed a close relationship between the instrument tip and the acceptable working length in teeth with and without resorption (Figs 5, 6). The overall mean distance between root tip and instrument tip was 0.62 (± 0.40) mm.

For the parameters evaluated, no statistically significant differences could be demonstrated between the groups with and without resorption.

Comparison of radiographs with cleared teeth

The agreement concerning the distance between the acceptable working length and instrument tip between clearing and radiographic computer supported measurement was 0.98.

Discussion

The use of radiographs during paediatric endodontic therapy should be considered carefully. The diagnostic value is often limited and exposure of children to X-rays should be limited. Alternatives such as tactile methods (Bagett *et al.* 1996), acoustic methods (Inoue & Skinner 1985) or electric methods (Czerw *et al.* 1995, Pratten & McDonald 1996, Vajrabhaya & Tepmongkol 1997, Dunlap *et al.* 1998, De Moor *et al.* 1999, Ibarrola *et al.* 1999, Weiger *et al.* 1999) have been suggested in the past. This method has also been proposed for primary teeth: an *in-vitro* study reported superior results of the root length determination by the Root ZX device compared to radiographs (Katz *et al.* 1996).

There are a number of factors that might affect electrical measurement of root canal length. One might

be the presence of root resorption, which often occurs physiologically in primary teeth. It may, however, be pathologically present in both permanent and primary teeth. Radiographic assessment of small areas of resorption is difficult, particularly in cases where resorption occurs on buccal or lingual aspects of the root. This will often not be visible radiographically, resulting in an increased risk of overinstrumentation and/or overfilling. Overfilling of primary teeth beyond the apex is associated with a reduced clinical outcome, at least with fillings containing Eugenol (Holan & Fuks 1993). Although there are alternative materials that may be less critical for overfilling in primary teeth, there is no doubt that overinstrumentation of a primary tooth can damage the germ of a permanent tooth (Nowak 1999). For this reason incomplete instrumentation has been indicated in those teeth which are seen in radiographs to be close to a tooth bud (Garcia-Godoy 1987). On the other hand, underfilling is also a risk factor for clinical success (Holan & Fuks 1993).

Hülsmann & Pieper (1989) demonstrated that an apex locator gave incorrect results in teeth with open apices. However, these authors used a first-generation apex locator, whereas a third-generation Tri Auto ZX device, that is less susceptible when used in similar conditions, was used in the present study.

The results of our study demonstrate that inter-examiner reproducibility of electrical determination of root canal length *in vitro* is high for primary teeth, both with and without initial root resorption. The accuracy of determination of the acceptable working length was also high compared with the radiographic results. The Tri Auto ZX device is calibrated by the manufacturer to measure the tooth length minus 0.5 mm. It has already been stated that the reliability of electrical root canal length determination is slightly higher than of radiographic assessment (Pratten & McDonald 1996). It should be noted that the radiographs used in our study were not taken *in vivo* and are probably of higher quality than those taken intraorally, which will include surrounding bone and potential loss of clarity through angulation.

Conclusion

Electrical determination of root canal length may support other diagnostic measures and increase the safety of treatment in specific situations such as the presence of root resorption.

Acknowledgements

The authors are grateful to Dr Ainie Lennon, Indianapolis, USA; Joanna Voerste, Kiel; and Dr. Gordon B. Gray, Bristol for their advice.

References

Bagett FJ, Mackie IC, Worthington HV (1996) An investigation into the measurement of the working length of immature incisor teeth requiring endodontic treatment in children. *British Dental Journal* **181**, 96–8.

Buchalla W, Attin T, Brücklmeier R, Hellwig E (1999) Computergestützte Methode zur quantitativen Bestimmung der apikalen Undichtigkeit von Wurzelkanalfüllungen. *Deutsche Zahnärztliche Zeitschrift* **54**, 244–8.

Coll JA, Sadrian R (1996) Predicting pulpectomy success and its relationship to exfoliation and succedaneous dentition. *Pediatric Dentistry* **18**, 57–63.

Czerw RJ, Fulkerson MS, Donnelly JC, Walmann JO (1995) In vitro evaluation of the accuracy of several electronic apex locators. *Journal of Endodontics* **21**, 572–6.

De Moor RJ, Hommez GM, Martens LC, De Boever JG (1999) Accuracy of four electronic apex locators: an in vitro evaluation. *Endodontics and Dental Traumatology* **15**, 77–82.

Dunlap CA, Remeikis NA, Begole EA, Rauschenberger CR (1998) An in vivo evaluation of an electronic apex locator that uses the ratio method in vital and necrotic canals. *Journal of Endodontics* **24**, 48–50.

Fuks AB, Eidelman E (1991) Pulp therapy in the primary dentition. *Current Opinion in Dentistry* **1**, 556–63.

Garcia-Godoy F (1987) Evaluation of an iodoform paste in root canal therapy for infected primary teeth. *ASDC Journal of Dentistry for Children* **54**, 30–4.

Holan G, Fuks AB (1993) A comparison of pulpectomies using ZOE and KRI paste in primary molars: a retrospective study. *Pediatric Dentistry* **15**, 403–7.

Hülsmann M, Pieper K (1989) Use of an electronic apex locator in the treatment of teeth with incomplete root formation. *Endodontics and Dental Traumatology* **5**, 238–41.

Ibarrola JL, Chapman BL, Howard JH, Knowles KI, Ludlow MO (1999) Effect of preflaring on Root ZX apex locators. *Journal of Endodontics* **25**, 625–6.

Inoue N, Skinner DH (1985) A simple and accurate way to measuring root canal length. *Journal of Endodontics* **11**, 421–7.

Katz A, Mass E, Kaufman AY (1996) Electronic apex locator: a useful tool for root canal treatment in the primary dentition. *ASDC Journal of Dentistry for Children* **63**, 414–7.

Nowak AJ (1999) *Pediatric Dentistry – the Handbook*, 2nd edn. Chicago, IL, USA: American Academy of Pediatric Dentistry.

Pratten DH, McDonald NJ (1996) Comparison of radiographic and electronic working lengths. *Journal of Endodontics* **22**, 173–6.

Vajrabhaya L, Tepmongkol P (1997) Accuracy of apex locator. *Endodontics and Dental Traumatology* **13**, 180–2.

Weiger R, John C, Geigle H, Löst C (1999) An in vitro comparison of two modern apex locators. *Journal of Endodontics* **25**, 765–8.

Yacobi R, Kenny DJ, Judd PL, Johnston DH (1991) Evolving primary pulp therapy techniques. *Journal of the American Dental Association* **122**, 83–5.

